Observations of the Relative Humidity in the Katabatic Wind Area, Mizuho Station in East Antarctica

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南極カタバ風帯みずほ基地での湿度観測

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要旨： 極域気水圏観測の期間中の 1979 年から 80 年に，湿度の長期観測をみずほ基地で行った．1979 年の測器はパナメトリック社の酸化アルミニウムの電気容量を測定するタイプであり，1980 年は EG & G 社の鏡面の霜を観測するタイプのものであった．低温でのこれらの測器の信頼度は必ずしも高くないが，ほぼ通年の観測から，冬のみずほ基地では，地上付近で少なくとも氷飽和の湿度になっている時が多いことが示唆された．

***Abstract*:** Two types of humidity sensors were available at Mizuho Station in 1979 and 1980. One was Panametric's hygrometer which measures the electric capacity of Al_2O_3 sensor, and the other was a mirror-type hygrometer made by EG &G. The result of humidity observations using these hygrometers suggests that the air at Mizuho Station in winter would be sometimes saturated in respect to ice.

1. Introduction

Due to the extremely low temperature and the continental climate, Antarctica is characterized by very low absolute humidity over the greater part of the region. As the absolute water vapor is very difficult to measure, it has been estimated as the saturation water vapor calculated from the air temperature. It is necessary to consider the saturation both over water and ice with the air temperature below zero. There is a possibility of cloud or frost to be formed in the condition of saturation over ice, so that the condition of saturation over ice is important for studying the formation process of cloud or frost.

At inland stations and stations in the katabatic wind area, SCHWERDTFEGER (1969), RUSIN (1964), SMILEY *et al.* (1976) and OHTAKE (1978) observed the clear-sky preciptitations or the growth of surface frost. However, the relative humidity or the absolute water vapor was not reported in their observations. If the variation of relative humidity or absolute water vapor was observed, the formation process of the clear-sky precipitation or surface frost would be known in detail.

RUSIN (1964) reported the monthly mean values of the relative humidity at sea stations and Graham Land stations, coastal stations and interior stations during the International Geophysical Year. The most humid region is West Antarctica, in particular Graham Land, where the average annual relative humidity exceeds 85%. On the coast the average annual relative humidity ranges from 60 to 85% according to the position of the stations. The relative humidity throughout the interior of the

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continent is over 70%.

Routine observation of the relative humidity has been carried out at Syowa Station from 1957. An automatic hair hygrometer and a ventilated psychrometer were used between 1957 and 1961, an electronic dew-point thermometer was used for a while from 1966, and a lithium chloride dew-point hygrometer has been used from 1966 at Syowa Station. The monthly mean values of the relative humidity at Syowa Station were recorded by JAPAN METEOROLOGICAL AGENCY (1981), when the annual relative humidity was about 65%. There were a few stations which observed the relative humidity in the katabatic wind area. One of them was at Pionerskaya where the average annual relative humidity was 76% according to RUSIN (1964).

POLEX-South (Polar Experiment in Southern Hemisphere Project) were carried out by the Japanese Antarctic Research Expedition (JARE) for three years from 1979 to 1981 around Syowa Station and Mizuho Station. The data of the relative humidity were obtained in 1979 and 1980. This paper reports the first observations of relative humidity of two years at Mizuho Station, and discusses the property of humidity there.

2. Instruments and Data Reliability

A model 2000 hygrometer by Panametric Co. was used in 1979 and a model 660 dew point hygrometer by EG&G was used in 1980 at Mizuho Station. Each sensor was set at about 1.5 m above the snow surface. Water vapor measurement with model 2000 hygrometer is made using an alminum film sensor coated with Al_2O_3 to measure the changes of the impedance of the film as water vapor in the atmosphere increases or decreases. Dew point temperature measurement is made using a direct-measuring sensor utilizing a Peltier-cooled, gold surfaced mirror, automatically held at the dew point temperature by an optical system. As condensate forms on the mirror, the optical system detects the change and develops a control signal to the power supply of the thermoelectric cooler. This power supply permits the mirror to continuously track the dew point.

An experiment for comparison between Panametric's hygrometer and EG&G's hygrometer was carried out in February 1980 by the members of the JARE-21. Although we could not compare the both hygrometers in the very low air temperature condition, we measured the air temperature between about -10 and -35°C by the both hygrometers at the same time. The results are shown in Fig. 1. The horizontal axis is the relative humidity over ice measured by EG&G's hygrometer and the vertical one is that by Panametric's hygrometer. A high correlation of the both values is recognized below about 75% relative humidity of EG&G's values, but above 75% the value of Panametric's are very larger than those of EG&G's and the correlation between them is not good. When the temperature is below 0°C, the hygrometer of EG&G detects the frost point, so that the humidity over ice does not exceed 100%. The humidity by Panametric's hygrometer, on the other hand, is obtained from the calibration curve of dew point, so that the humidity over ice exceeds 100%. A reason of the discrepancy between the values of the both hygrometers below 75% humidity of EG&G's would be derived from the sensor of Panametric's hygrometer, which had been already used for a year.

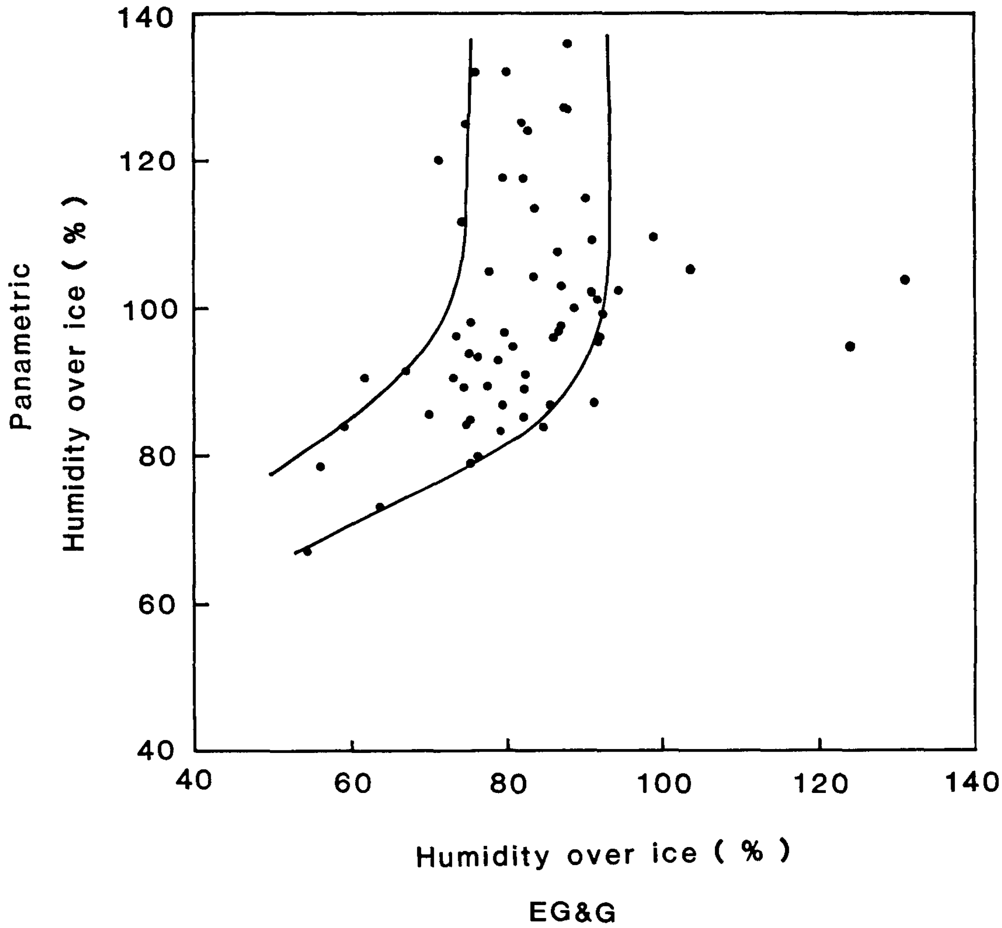

Fig. 1. The comparison between Panametric's hygrometer and EG&G's hygrometer in February 1980.

The data of these hygrometers are referred to WADA *et al.* (1981) and OHATA *et al.* (1983). The data of temperature at Mizuho Station are referred to WADA *et al.* (1980) and OHATA *et al.* (1981).

3. Results

Figure 2 shows the monthly mean relative humidity and the air temperature at Syowa Station in 1979 and 1980. The relative humidity over water (RHW) is defined as follows:

$$RHW=\frac{e}{e_s(t)}\times 100 \qquad (1)$$

where e is the observed water vapor pressure and $e_s(t)$ is the saturation vapor pressure over water at the t°C air temperature. The air temperature in 1980 was higher than that in 1979 every month but the humidity of winter was higher in 1979 and that of summer was higher in 1980. The humidity throughout two years was 50 to 70%.

Figure 3 shows the monthly mean relative humidity at Mizuho Station in 1979 and 1980 and the saturated humidity over ice in 1979 which is obtained by eq. (1) from the saturation vapor pressure over ice under the monthly mean temperature.

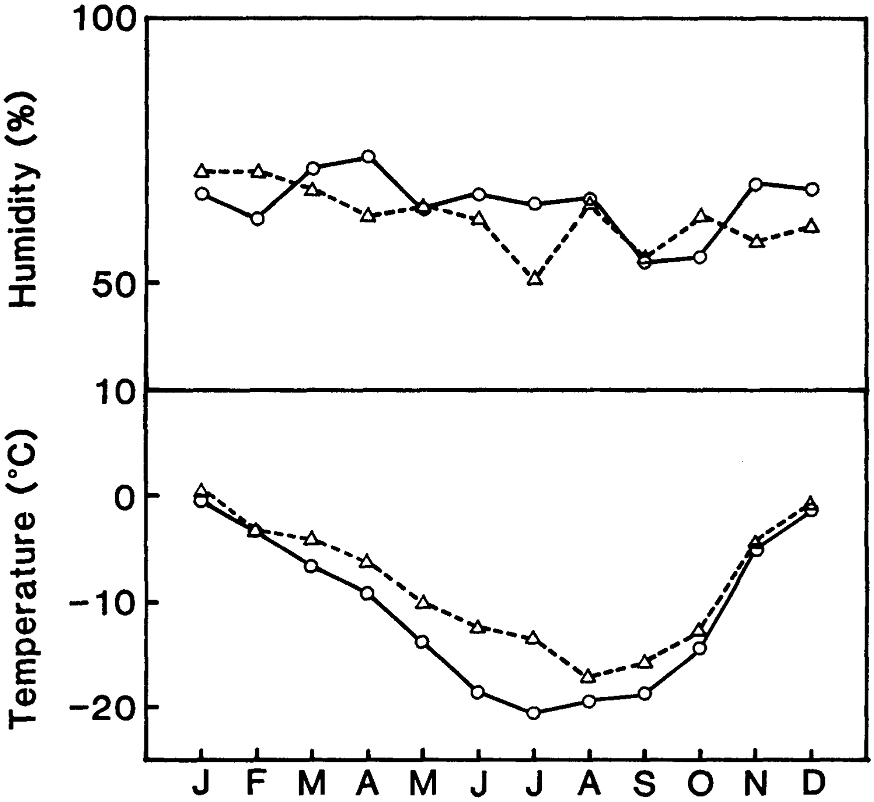

Fig. 2. The monthly mean relative humidity and the air temperature at Syowa Station in 1979 (solid line) and 1980 (broken line).

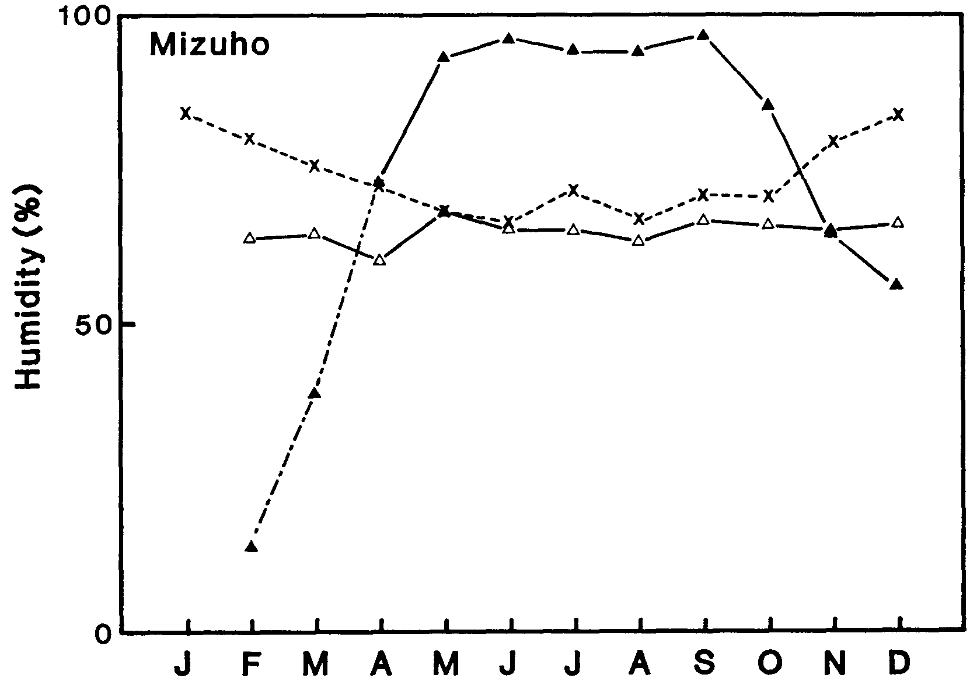

Fig. 3. The monthly mean relative humidity at Mizuho Station in 1979 (solid triangle) and 1980 (open triangle) and saturated humidity over ice calculated by the temperature of 1979 (broken line).

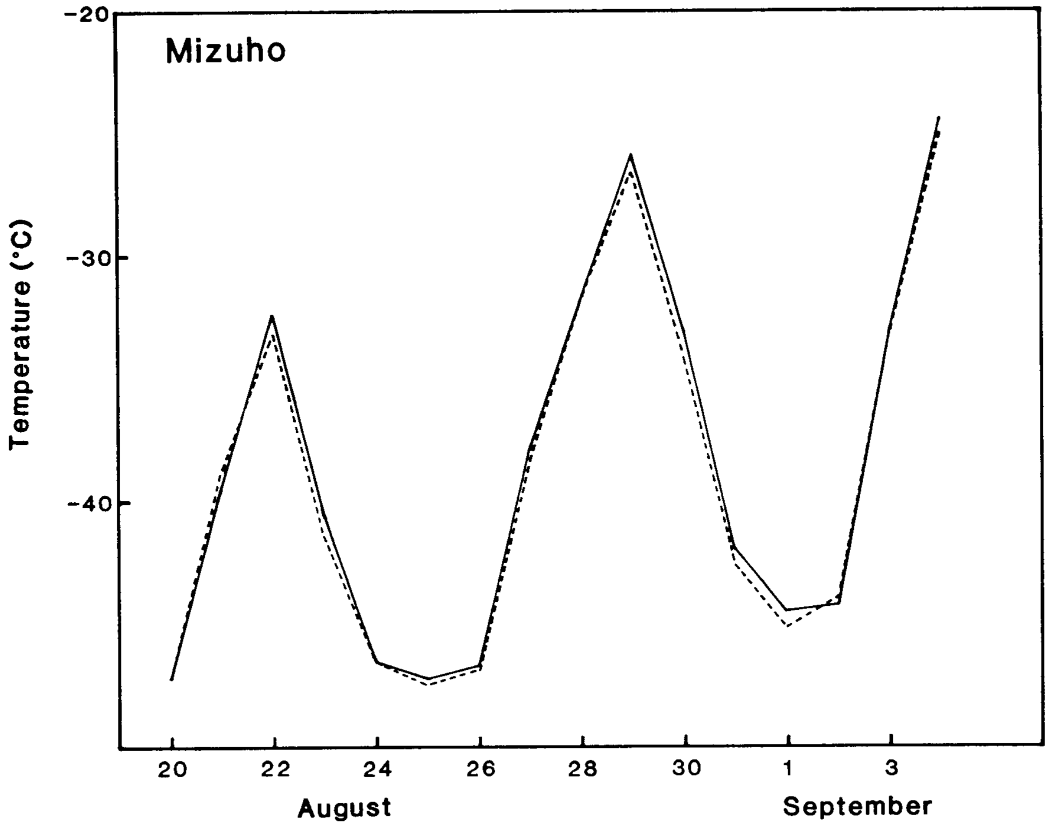

Fig. 4. The daily mean temperature (solid line) and the frost point temperature (broken line) from August 20 to September 4 in 1980.

The humidity over ice was supersaturated from May to October in 1979. The relative humidity was about 65% in 1980 and the humidity over ice was nearly saturated from May to October in 1980.

Figure 4 shows the daily mean air temperature and the daily mean frost point temperature measured by the mirror-type hygrometer during the period from August 20 to September 4 in 1980. The difference between the air temperature and the frost point was less than 1°C, namely, the air is almost saturated in respect to ice.

4. Discussion

The humidity data of 1979 and 1980 suggest that there would be days when the water vapor was saturated in respect to ice during the period from May to September or October at Mizuho Station as shown in Figs. 3 and 4, despite of the unreliability of the sensors as stated in Chapter 2.

Figure 5 shows the monthly mean humidity and the air temperature at Mirny, Pionerskaya and Vostok II after RUSIN (1964). A graph of the relative humidity of saturation vapor over ice derived from monthly mean air temperature at Pionerskaya is also shown in Fig. 5. According to the figure, the humidity over ice at Pionerskaya was supersaturated from March to December. At Vostok II the condition of supersaturation water vapor over ice occurred throughout the year, according to the data of monthly mean relative humidity and air temperature as shown in Fig. 5. At Mirny,

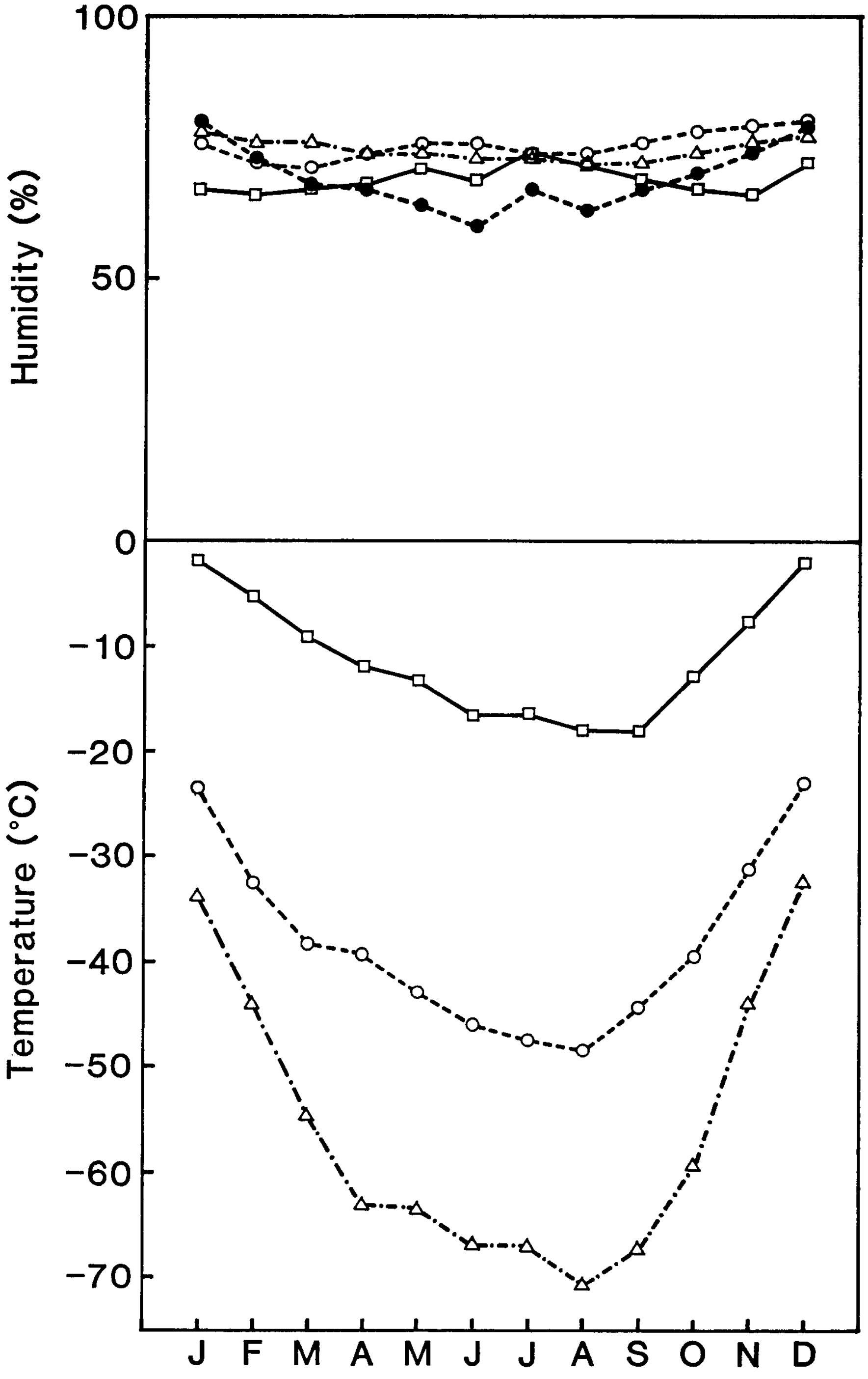

Fig. 5. The monthly mean relative humidity and the air temperature at Mirny (square), Pionerskaya (open circle) and Vostok II (triangle) and saturated humidity over ice calculated by the temperature of Pionerskaya (solid circle). Period of observations at Mirny is 1956–1959, at Pionerskaya, 1956–58 and at Vostok II, 1958–1960.

however, the air temperature was as high as at Syowa Station, so that the humidity over ice was unsaturated. Pionerskaya is located in the katabatic wind area and the monthly variation of air temperature at Pionerskaya is similar to that at Mizuho Station. This result shows that the humidity over ice is often saturated from late autumn to early spring in the katabatic wind area 200 or 300 km inland.

The condition will be related to the formation of surface frost and the clear sky precipitation in the low temperature season. I describe one example of the condition at Mizuho Station. It was reported (WADA *et al.*, 1980) that the visibility was 400 m in spite of not so strong wind (8 m/s) on July 20, 1979. This visibility was unusual, because the visibility was usually about 1 km at 8 m/s wind speed in July at Mizuho Station, where the visibility depends on wind speed because of drifting snow. The air temperature at that time was $-52.5^\circ C$. It would be possible that the water vapor was saturated in respect to ice and ice crystals were floating near the surface at that time. At Mizuho Station it is difficult to distinguish between drifting snow and floating ice crystals as the wind is usually strong (more than 10 m/s), especially in the winter season. Considering from saturation water vapor over ice at Mizuho Station, the low visibility in winter would be attributed not only to drifting snow with strong wind but also to floating ice crystals near the surface.

5. Summary and Future Problems

Considering from the humidity observation at Mizuho Station in 1979 and 1980, the air would be often saturated in respect to ice near the snow surface during the period from May to September in winter. Since drifting snow occasionally occurs due to strong wind, it is difficult to observe the condition of saturation water vapor over ice at Mizuho Station. It will be necessary to measure the humidity accurately when the water vapor is supersaturated in respect to ice and develop a new way of measurement available under low temperature.

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